ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

Draft Report

Energy Efficiency in California High-Tech Facilities
Cleanroom Energy Design Charrette
Genentech B7 CPMF project
South San Francisco, CA

W. Tschudi, D. Sartor
Energy and Environment Division

October, 1999

Energy Design Charrette
Genentech, South San Francisco, CA

Executive Summary

At the request of Genentech's Gary Shamshoian, Lawrence Berkeley National Laboratory (LBNL) facilitated an energy design "charrette" for the B7 Clinical Parenteral Manufacturing Facility (CPMF) project on October 19, 1999. In this exercise, the Genentech stakeholders, and the designer, participated in a process which was designed to examine the opportunity for energy saving for the project. A four-hour "charrette" (brainstorming) session was held which began with a discussion of goals and concepts for the project. Next, the group discussed constraints encountered for this project. The constraints were then lifted for a discussion of ideas for an idealized design (with no constraints). Finally, the group attempted to apply idealized principals to the actual project. In the process, the group came up with numerous ideas for attaining energy efficiency. By far, the largest energy use is associated with the cleanroom HVAC system. Areas of focus included issues related to minimizing air flow, controlling airflow for various occupancies, minimizing reheat, and minimizing system pressure drop. In addition, the group suggested other areas such as lighting controls, for further investigation. This report documents the discussion in more detail. This report of the charrette process and specific project issues is being presented for information which can be further examined for use by Genentech on this project or used for future designs. This charrette and continuation of this process should assist in meeting Genentech's energy efficiency goals.

Background

LBNL has been engaged in research of energy efficiency for high tech buildings through and initiative sponsored by the California Institute for Energy Efficiency, and the California Energy Commission. Through this initiative, LBNL has been working with industry partners to identify the opportunities for energy efficiency improvement and is engaged in ongoing research in a number of areas important to cleanroom energy efficiency.

As part of this initiative, an energy design charrette was planned to demonstrate the usefulness of this technique in the design of a cleanroom project. Charrette is a term used in the architectural community to describe a process for critiquing and improving a building design.

> The term "charrette" is adopted from the storied practice of Ecole des Beaux Arts architectural students in nineteenth century Paris who reputedly could be seen still drawing their projects until the last minute as they were carried on the "cart" or en charrette on the way to the design jury. In its modern-day adaptation, charrette refers to an intensive design workshop involving people working together under compressed deadlines.

LBNL solicited high tech firms within California to find a project appropriate for a charrette. The Genentech project was selected as representative of a typical Biotechnology cleanroom buildout. The timing for the charrette was at the conceptual design stage. This is ideal for performing a charrette to allow for energy saving ideas to be considered as the design develops.

The charrette process provided valuable feedback for use as a design aid and provided LBNL with valuable industry feedback on a wide range of research issues such as more efficient HVAC design. The fact that the design was in the conceptual stage allowed for a free exchange of ideas for alternate designs.

A team of energy professionals and a facilitator were provided by LBNL to facilitate the charrette. LBNL also coordinated participation by PG&E who provided an energy consultant. Genentech assembled a team of facility and process engineers, the designer, and management familiar with the project and the overall site. Gary Shamshoian of Genentech led the charrette. A list of the B7 CPMF charrette participants is attached.

The project involved approximately 18,000 sq.ft. to be constructed in the third floor of a new building originally designed for laboratories. The first two floors will have been constructed and operating late in year 2000, before construction of this space. As such construction will be planned so as to not disturb existing operations.

Since the project utilizes existing utility services such as chilled water, water for injection, steam, compressed air, etc., there would be little opportunity to impact the design of those systems. The review team therefore primarily focused on the HVAC air systems which account for the majority of the non-process energy use. This focus also allowed for more in-depth discussion on this topic in the time allowed for the charrette.

Charrette Process

There are many ways to structure a charrette. To prepare for the charrette, LBNL first attended an informational meeting to become familiar with the project, and some of the project team members. Prior to the charrette, LBNL contacted the design firm to determine the status of the conceptual design and explain the charrette process. A previous conceptual study provided most of the project definition. The design team had just been authorized to proceed with the schematic design so there was little definitive design information.

For the charrette, Genentech invited its key stakeholders including facility engineers, process engineers, quality control staff, HVAC supervisor, and key design staff. This team was experienced with site issues, and was familiar with this project. The mechanical design engineers were included in the meeting, and contributed greatly to defining initial design concepts and brainstorming for energy efficient design. It would have been useful to have full participation by the design team, however travel cost and other commitments precluded this.

The team first defined the goals of the project and described the conceptual design completed to date. They then identified constraints to achieving energy efficiency unique to this project. The constraints included typical constraints present in most projects such as budget, use of standards, etc., as well as project-specific constraints such as build-out of an existing shell, ceiling height, etc. The team then "lifted" all the constraints, and brainstormed ideas for an efficient design. These best practices ideas were not limited by any of the practical limitations on the project. Finally, the team focused on the B7 Clinical Parenteral Manufacturing Project and sought to merge the best practices ideas with the identified constraints. The discussion generated through the charrette process for these categories are listed below:

Goals/Facts

- Manufacture of product targeted for European market. New facility must meet Genentech, FDA, and European (ISO) standards.
- Tie into existing central plant systems. Chilled water, steam, nitrogen, etc. will be provided from the central system.
- HVAC system will be separate system from first two floor's system.
- Rooms will involve product in open
- Sterility is major concern – not particulates
- Programming document developed by the engineer and approved by Genentech
- Building will be leased
- Building designed for labs on first two floors with build out later for additional labs on third floor. Now use is changing for third floor.
- Plan is to have HVAC operate with constant volume and control to constant temperature. VAV would be provided to account for filter loading primarily.
- Room pressures cascade from most clean space to least clean space
- 100% emergency power back-up
- Exhaust is not significant. Make-up air is driven by pressurization losses.
- Fan energy could represent up to 80% of the facility energy use (exclusive of the central plant systems).

- Third floor would operate for two shifts so potential for turn-down exists.

Constraints

- Budget – Capital budget essentially fixed, however some opportunity to evaluate options for significant pay back.
- Building shell, structure, ceiling height etc. will exist and cannot be modified
- Continuous operation –The two lower floors of the building will be operating 24 hours a day by time the construction begins on the third floor and have to be kept operating.
- Capacity of existing site utilities – New facility and process equipment for this project were constrained to use existing chilled water at 42 degrees, compressed air at 100 psi and –100 degree dew point, etc.
- Loads are limited to 25W/sq.ft. due to 100% emergency back-up capacity, or else would be subject to loadshed.
- Once criteria such as temperature variation are established, Q/A and FDA will expect them to be met.
- Temperature control, although not critical to the process, is important for worker comfort.
- No ductwork on the roof for aesthetic reasons
- Redundancy of some systems
- Humidity control – although the control range is not overly tight, having a humidity control requirement limits some options for energy efficiency
- Standardization –Genentech tries to be consistent between projects to facilitate FDA approvals. Repeatability and standardization sometimes limits energy saving options.
- FDA Requirements-Current Good Manufacturing Practices as interpreted by the FDA tend to discourage certain energy saving measures.
- Provide laminar flow at work surface
- Energy Efficiency savings are often small compared to potential cost of regulatory questions.
- Room width constraints to achieve class 100 with side returns.

Idealized design - B7 CPMP Design

- Optimize HVAC scheme – Use a larger air handler/ plenum, variability - Use of VFD for recirculated air.
- Localized strip curtains for critical areas to reduce cross flow.
- Include energy efficiency requirement in equipment specifications. Since major equipment has not been specified there is time to include energy efficiency requirements in the specifications.
- Optimize airflow and distribution schemes – Consider make-up air tie-in to inlet of recirculation path. Consider larger duct sizes, lower face velocities, smooth changes of direction, bottom outlet from recirculation unit. These measures will minimize pressure drop.
- Use a lower face velocity on the make-up air handler. Target 2” maximum pressure drop in system. Use face velocity of 250-400 fpm.
- Use lighting controls for unoccupied times.
- Use efficient motors, T-8 lighting
- Work with air handler manufacturer to optimize size of unit. Ie: larger box and smaller fan.
- Implement comprehensive commissioning plan

A focused discussion and brainstorming for three key issues took place. These were:

Minimizing reheat

- Consider separate cooling coil for high heat areas
- Reset supply temperature
- Increase the number of primary air handlers

Minimizing Pressure drop

- Low pressure drop rigid mini-pleat HEPA filters in make-up air handling units.
- Use 30% 4” pleated filters on the make-up air intake only. Replace these filters regularly – minimum of every three months.
- Use a low face velocity on the make-up air handler. The target total pressure drop should be 2”.
- Increase ceiling coverage in order to reduce velocity. Since pressure drop is proportional to the square of the velocity, a small decrease in filter velocity has a large impact on pressure drop.
- Recommend 60-70 feet per minute velocity at the face of the ceiling HEPA filter.
- Once a lower pressure drop system has been designed, fan noise will be significantly reduced. Thus noise attenuating devices will not be required.

- Alternative coil placement
- Use 95% or 99% HEPA filters on all cleanrooms of class 1,000 or higher.

Minimizing average air flow

- Use VFD on “secondary” or recirculation fans
- Use demand controlled ventillation techniques. Where possible, lower fan speeds and air changes in cleanrooms when they are unoccupied. Consider using particle counting sensors connected to variable speed recirculation air handlers where appropriate. Control based upon occupancy, load, and/or cleanliness.
- Use lower limits when there is a recommended range of air changes in cleanrooms.

Recommendations

Based upon the team’s suggestions and the discussion at the design charrette, we offer the following recommendations:

1. Establish a requirement to include energy efficiency as a selection criteria in product specifications.
2. Establish a procedure to perform cost-benefit analyses utilizing life-cycle cost, not simply first construction cost. This procedure would consider operating cost including energy cost, maintenance cost, etc.
3. Review Genentech standards, and FDA interpretation of cGMP for cleanrooms and update them for energy efficiency considerations.
4. Request (and verify) wattage required for facility system and process equipment. Determining the actual operation wattage via measurement of similar process equipment in operation would be ideal and allow for designing for the real load, not just the maximum possible wattage, which is often much higher than the actual operation consumption.
5. Investigate use of demand-controlled ventilation controlled by cleanliness and/or occupancy given that the space will not be occupied 24 hours per day.
6. Research fan manufacturers and select fans for the highest energy efficiency possible. Set aggressive targets for efficiency and work with manufacturers to set dimensions resulting in efficient operation. Fans at 10 hp or greater should be selected at 75% or higher efficiency.
7. Encourage (incentivize) the architect engineer to actively contribute energy saving ideas and participate in energy charrettes. By implementing Recommendation #2, make the operating cost (energy efficiency) one of the design constraints.
8. Evaluate controls options and resulting efficiency for various schemes of controlling the HVAC units including variable volume.
9. Design for high chilled water temperature drop across coils – minimum of 14 degrees.
10. Use two way valves on chilled water and hot water coils – variable flow design.

Summary

The energy design charrette demonstrated a process for obtaining better energy efficiency in cleanroom applications. The charrette at Genentech included good participation and a lively discussion of approaches to energy issues. The process was effective in identifying a number of energy considerations and should be utilized at the early stages of any new or retrofit project. A similar procedure might aid in the creation of general energy conservation guidelines (an energy guidelines charrette) that could be implemented by Genentech to influence all future Genentech cleanroom design projects.

GENENTECH/LBNL ENERGY DESIGN CHARRETTE

October 19, 1999

ATTENDANCE

Genentech

Project management
Process engineering
Facilities engineering
Electrical engineer

Architect-Engineering firm

HVAC engineers

Lawrence Berkeley National Laboratory

Bill Tschudi	510-495-2417
Dale Sartor	510-486-5988
Rick Diamond	510-486-4459

Supersymmetry (LBNL consultant)

Peter Rumsey	510-663-2070 X201

Southern Exposure Engineering (PG&E consultant)

Keith Rothenberg	415-206-9368